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ARSENATE OF LEAD AS AN INSECTICIDE AGAINST THE TOBACCO HORNWORMS IN THE DARK-TOBACCO DISTRICT.

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INTRODUCTORY.

In the dark-tobacco districts of Kentucky and Tennessee tobacco hornworms (*Phlegethontius quinquemaculata* Haw. and *P. sexta* Joh.) are the ever-present and most serious problem of the tobacco grower. Ten to twelve years ago, when labor was plentiful, cheap, and efficient, "hand worming" was found to be economical and effective in combating this pest. However, during the last six or eight years hand worming has become too costly, because of the great scarcity and inefficiency of labor, and the growers have been forced to employ an insecticide. At the time insecticides were first used Paris green was found to be the safest and most efficient. Nevertheless, there has always been complaint of frequent serious burning of tobacco as a result of its use. To find a safe and effective insecticide has been one of the main lines of investigation during the past five years. Arsenate of lead (diplumbic) has been found to meet the requirements.

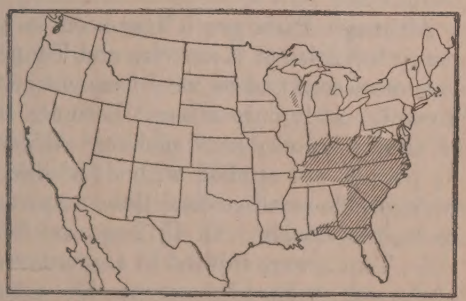

FIG. 1.—Map showing distribution of the tobacco hornworms in the United States.

NECESSITY AND ADVANTAGES OF THE USE OF AN INSECTICIDE.

The effect of the scarcity of labor in bringing about the use of an insecticide upon tobacco has already been explained. In addition to this necessity of using a poison, the much greater efficiency

NOTE.—This bulletin is intended to assist the tobacco growers of Kentucky and Tennessee and the adjoining States in combating a troublesome pest.

of a good application of an insecticide is another strong argument in its favor. Hand worming, even of the best, has many objections; for instance, eggs are not picked off, many small worms are overlooked, and, lastly, during the hot hours of the day large worms crawl down into the "ruffles" near the bases of the leaves, and a considerable number are thus overlooked. On the other hand, a thorough application of an insecticide will kill practically every hornworm—except those very nearly full grown—within two or three days, and will also continue to kill the young worms that hatch several days after the application. In short, hand picking has only an immediate effect in lessening the worms, whereas the application of an insecticide usually continues to kill over a period of several days. Cheapness is another point very greatly in favor of an insecticide as compared with hand picking. The cost of keeping an acre of tobacco hand wormed in a year when worms are plentiful is variously estimated at from $6 to $10. A like number of worms can be killed with Paris green at a cost of not more than $2 per acre, and with arsenate of lead at a cost of from $3 to $5 per acre.

INJURY TO TOBACCO BY THE USE OF PARIS GREEN.

Although Paris green has been in general use upon tobacco in many localities of Kentucky and Tennessee for more than a decade, yet, on account of its very frequent serious injury to tobacco, many growers use it only after it becomes too costly to keep the worms off the tobacco by hand picking. Occasionally dosages of 2 and even 2½ pounds are applied without visible injury. On the other hand, unfavorable weather conditions may cause dosages of 1 to 1½ pounds to burn seriously. In 1912 several fields in the vicinity of Clarksville, Tenn., were injured in amounts varying from 10 to 25 per cent of the gross value of the crop. The usual loss, however, is not greater than 4 or 5 per cent.

Paris green injures tobacco in two ways: First, by causing dead, burned areas upon the leaves, where the powder has been collected by the dews or washed down by the rains; second, by weakening the leaf at the stalk. Light rains wash the insecticide into the axils of the leaves, and the result is that many leaves drop off before cutting time or become so weakened that they drop off when the plant is cut. Although such leaves are not a total loss, for they are collected and cured, yet they are a partial loss, for they lack weight and elasticity.

ADVANTAGES OF THE USE OF ARSENATE OF LEAD.

Arsenate of lead causes none of the injury just mentioned. Experiments performed under the direction of the senior writer show that powdered arsenate of lead may be put on a fresh sucker wound

in large quantities without causing any noticeable injury, and that when applied to a torn or bruised leaf it produces no injury. Paris green can not be applied to tobacco in the "graining" stage (i. e., when nearly ripe) in sufficient quantities to do good insecticidal work without too grave danger of burning the plant. Arsenate of lead, on the other hand, can be safely applied to tobacco in the "graining" stage in quantities sufficient to produce satisfactory insecticidal results. Furthermore, arsenate of lead will cause no irritation to the operator as will Paris green; in fact, thus far it has produced no noticeable injurious effects upon the operators.

RESULTS THAT HAVE BEEN OBTAINED FROM THE USE OF ARSENATE OF LEAD.

APPLICATIONS IN FAIR WEATHER.

On August 24, 1910, Paris green was applied to a plat of tobacco at the rate of 1½ pounds per acre. On the third day after the application 95 per cent of the worms were dead. However, on the fifth day after the application numbers of small worms were seen upon the tobacco, which indicated that the dosage was losing its effect. On August 25, 1910, powdered arsenate of lead was applied, in the same field, to one plat at the rate of 5 pounds per acre and to another plat at the rate of 3½ pounds per acre. On the fourth day after the application about 99 per cent of the worms had been killed by the 5-pound dosage and about 89 per cent by the 3½-pound dosage. Both dosages of lead arsenate continued to kill worms for several days after the Paris green had lost its effect.

The foregoing applications were made under the most favorable conditions; that is, while dew was upon the plants and while there was no breeze. The tobacco was about two-thirds grown.

On August 21, 1911, a dosage of arsenate of lead at the rate of 4⅜ pounds per acre was applied during a breeze. At the expiration of four days only 78 per cent of the worms were dead. On the same date and under the same conditions an application of Paris green at the rate of 1¾ pounds per acre killed only 54 per cent of the worms in four days. These experiments emphasize the necessity of making the application of an insecticide when there is *very little breeze.*

APPLICATIONS IN RAINY WEATHER.

On August 28, 1911, arsenate of lead was applied about 7 a. m. to two plats of tobacco at the rates of 5 pounds and 4 pounds per acre, respectively, and Paris green was applied to the check plat at the rate of 2½ pounds per acre. The same day between 11 a. m. and 2 p. m. about one-third of an inch of rain fell in dashing showers. On the second day after the application 91 per cent of the worms had been killed by the 5-pound dosage of arsenate of lead, 83 per cent by the

4-pound dosage of arsenate of lead, and only 66 per cent by the 2½-pound dosage of Paris green. On the fourth day after the application the number of worms on the 5-pound dosage arsenate-of-lead plat was still further reduced. On the other hand, the worms had increased in numbers upon the 4-pound dosage arsenate-of-lead plat and on the Paris-green plat. These results indicate that arsenate of lead can be made effective under conditions under which Paris green is practically a failure.

EXPERIMENTAL ACRE AT CLARKSVILLE, TENN.

During the summer of 1913 an experimental acre of tobacco at Clarksville, Tenn., was kept free of worms by the use of powdered arsenate of lead from the time worms appeared in destructive numbers until worms ceased to appear. Four applications were made, using a total of 12¼ pounds, an average of a little more than 3 pounds per dosage. However, the first dosage was too light, only 2½ pounds, and had to be repeated. Had the first dosage been at the rate of about 4 pounds per acre, undoubtedly two more dosages of about 3½ pounds per acre would have been sufficient to do the work accomplished by the four applications. The total cost of the arsenate of lead and labor (assuming the arsenate of lead to retail at 25 cents per pound) was only $3.86, an average cost of 77 cents per week for the five weeks over which the dosages remained effective.

The first dosage was applied while the worms were small, and the repetition of the dosages at intervals of about 10 days prevented the growth of large worms. No hand worming was done upon this acre and no tobacco was injured either by the worms or by the arsenate of lead.

THE 4-ACRE FIELD AT PEMBROKE, KY.

On August 12, 1913, 4 acres of large tobacco upon the farm of Mr. R. Y. Pendleton, at Pembroke, Ky., were given an application of 5¼ pounds per acre of powdered arsenate of lead. At the time of the application the worms averaged two per plant. On August 14, or two days later, only four live worms were found on the entire field. The examination was made by walking across the field in opposite directions and examining numerous plants. There was no injury to the tobacco from poison burn. No more poison was applied to this field and practically no hand worming was necessary during the remainder of the season. This very remarkable result is explained in part by the fact that very little rain fell during August, and by the fact that comparatively few eggs were laid upon this tobacco after the middle of August. If worms had been numerous during the latter part of August and the weather rainy, undoubtedly another application would have been required.

The results upon this field emphasize the fact that a clean sweep of the tobacco worms can be made with arsenate of lead without danger of burning the tobacco. The tobacco in this field was well advanced and at a stage in which Paris-green burn was very likely to occur.

HOW TO APPLY ARSENATE OF LEAD TO TOBACCO.

Paris green is generally applied to tobacco by means of a dust gun and without the admixture of a carrier. On the other hand, arsenate of lead must be mixed with a carrier in order to secure an even and thorough distribution. Several carriers have been tested with this insecticide. Finely sifted air-slaked lime did not dust evenly. Road dust and land plaster proved to be too heavy. The best results were obtained with finely sifted, freshly burned wood ashes. At least an equal bulk of the wood ashes should be used. Mix the arsenate of lead and ashes very thoroughly and apply while there is dew upon the tobacco and when there is no breeze. Even if very dry and finely sifted ashes are used, unsatisfactory results will be obtained unless the application is made with a powerful dust gun. The hand-power dust guns now in general use do not furnish sufficient power to make anything like a satisfactory and effective application. Special guns that will perform satisfactory work are gradually coming on the market. The new guns have a fan with a diameter of 8 inches, whereas the old guns have a fan diameter of only 6 inches. The new guns have also an auxiliary dust chamber, which is very essential, because the dust containers of the old guns are so small that they have to be refilled five or six times for each acre dusted. Two refillings of the new guns will be sufficient for dusting an acre.

To secure the best results, dust the tobacco when dew is upon the plants and when there is no breeze. The use of a carrier that does not dust evenly, the application of the insecticide when there is too much breeze, and the use of too small a dust gun are all certain to give unsatisfactory results. Avoid these mistakes, and satisfactory results will be secured.

Thoroughness of application can not be too strongly recommended. When tobacco worms are numerous a poor application of an insecticide will miss worms enough to ruin in two days more than enough tobacco to pay for the whole application. Make the application thorough.

THE GRADE OF ARSENATE OF LEAD THAT SHOULD BE USED.

Arsenates of lead may be broadly divided into two forms, triplumbic and diplumbic. Theoretically the triplumbic form may contain 25.58 per cent of arsenic oxid, while the diplumbic may

contain 33.15 per cent of arsenic oxid. Experiments have shown that the triplumbic form is too slow in its insecticidal action to justify its use against tobacco hornworms. The diplumbic form is the one that should be used. *In order to be sure of receiving the diplumbic form, demand that the manufacturer and dealer guarantee that the arsenate of lead you buy contains at least 30 per cent of arsenic oxid* (As_2O_5) *in which not more than 1 per cent is free or water-soluble.* This grade was the one used in all the experiments mentioned in this bulletin. It is necessary to have a low percentage of free, or water-soluble, arsenic in order to insure against burning the tobacco.

WHEN TO APPLY ARSENATE OF LEAD.

The first application of arsenate of lead should be made when tobacco worms become too numerous to be kept off tobacco by the hand-picking that is usually done while hoeing, suckering, or topping tobacco. In some years a second and even a third application may be necessary. The time for making these applications will be indicated by the numbers of eggs and young worms appearing on the tobacco. For further discussion of this heading see figure 2.

DOSAGE OF ARSENATE OF LEAD REQUIRED.

When tobacco is small and has not begun to lap in the row an application of 3½ pounds of arsenate of lead per acre will be efficient if carefully made. Full-grown tobacco should receive not less than 5 pounds per acre. Of course the weight of the ashes or other carrier used is in addition to the weight of the arsenate of lead. In water spray use not less than 3 to 4 pounds per 100 gallons of water.

COST OF ARSENATE OF LEAD.

The special grade of powdered arsenate of lead recommended for use on tobacco will cost about 22 cents per pound at the factory in 100-pound kegs. The freight will be about 1 cent per pound, making the total cost 23 cents per pound to the grower. Therefore a 3½-pound dosage will cost about 80 cents, while a 5-pound dosage will cost $1.15. In 1913 powdered arsenate of lead retailed at Clarksville, Tenn., for 25 cents per pound. A 2-pound dosage of Paris green costs from 50 to 55 cents, while a dosage of 1¼ pounds, which is the smallest which should be applied, will cost about 31 to 35 cents. If the comparative cost of Paris green and arsenate of lead were the only question to be considered, it would be useless to recommend arsenate of lead. The cost, however, for the careful grower should be a matter of strictly secondary consideration. The certainty of not burning the tobacco should more than compensate for the extra cost of this insecticide.

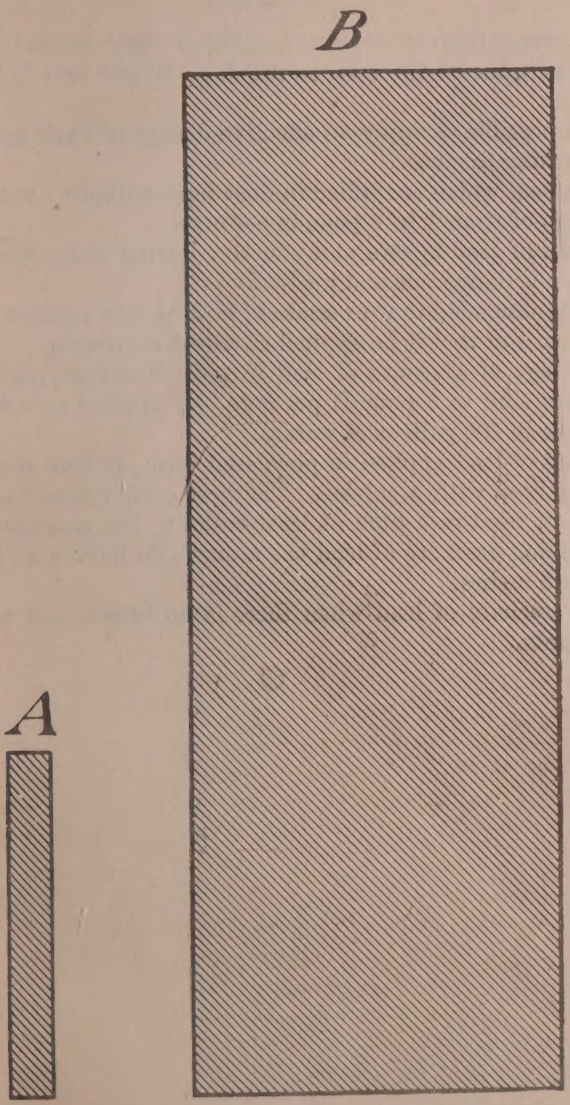

FIG. 2.—Amount of leaf surface of tobacco eaten by hornworms from time of hatching to completion of growth.

A represents one-sixteenth of the amount eaten in the first 9 days; *B* represents one-sixteenth of the amount eaten in the last 10 to 11 days.

During the first 9 days of its life the tobacco hornworm eats about 7⅞ square inches of leaf surface, while during the last 10 to 11 days of its life it eats about 191½ square inches—25 times the amount eaten during the first 9 days. *This statement should suggest the proper time for applying arsenate of lead to tobacco, which is while the worms are small—that is, while they are easy to kill and before they have done much damage to the tobacco.* Repeat the application as soon as numbers of small worms appear upon the tobacco.

SUMMARY.

Paris green frequently burns tobacco very severely, and may reduce the value of the crop as much as 50 per cent in exceptional cases.

It is impossible to apply an effective dosage of Paris green without risk of burning tobacco.

Paris green, which is applied in dust form without a carrier, is used at a dosage of from 1 to 2 pounds per acre.

Arsenate of lead is safe and effective during rainy weather, while Paris green is dangerous and ineffective.

It is recommended that arsenate of lead be used against the tobacco hornworms, and that it be applied as a dust or powder.

The dosage of arsenate of lead in powdered form varies from 3½ pounds per acre to 5 pounds per acre. If applied as a spray, use 3 to 4 pounds in 100 gallons of water.

Arsenate of lead applied in powdered form, as here recommended, must be mixed with a carrier. The best carrier found so far is dry wood ashes, used in a bulk at least equal to the arsenate of lead.

In applying arsenate of lead use a dust gun having a fan diameter of at least 8 inches.

Apply arsenate of lead when there is no breeze and when dew is on the plants.

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